Employing Organizational Modeling and Simulation to Deconstruct the KC-135 Aircraft's Programmed Depot Maintenance (PDM) Flight Controls Repair Cell

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OUTLINE

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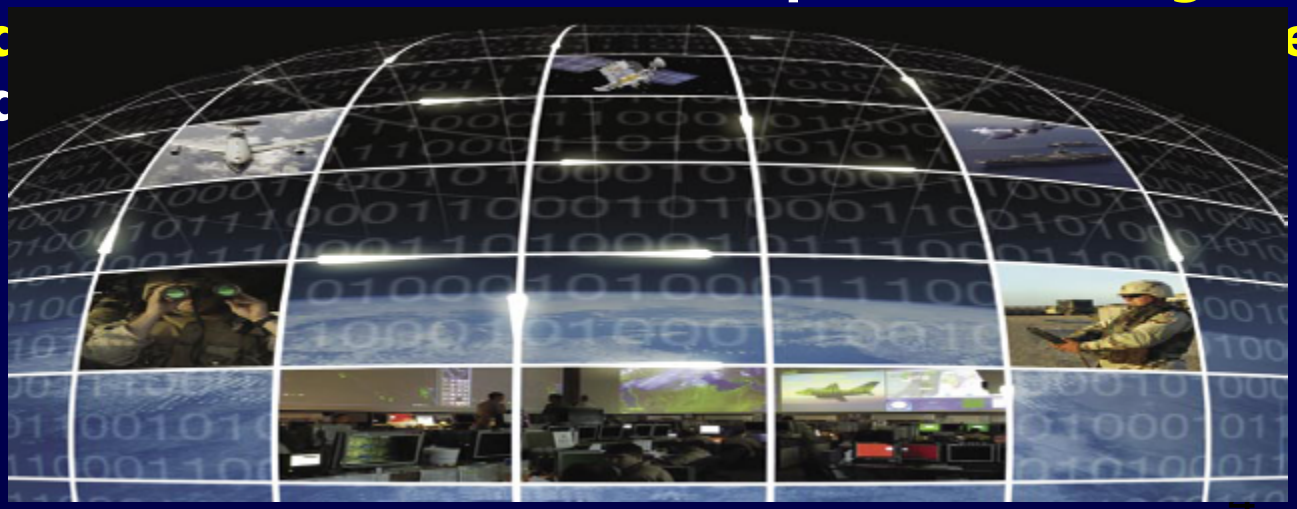
BACKGROUND

- **Aim: improve KC-135 flight controls repair process**
  - **Aging fleet (avg. is 46+ yrs)**
  - **Increasing Programmed Depot Maintenance (PDM) demands**
  - **Flight Controls Repair Cell, 564th Aircraft Maintenance Squadron, 76th Aircraft Maintenance Group, Oklahoma City ALC, Tinker AFB OK (a.k.a. the HV Repair Cell)**
- **Focus on HV Repair Cell's internal formal & informal communication flows & information processing using Computational Organizational Modeling (COM)**
- **Introduce what-if scenarios ("*interventions*") to analyze potential organizational design changes**
  - **Evaluate impact on simulated repair cycle-time, cost, & risk**
- **Support DoD transformation initiatives like AF Smart Operations for the 21st Century (AFSO21)**

BACKGROUND (cont.)

- **How COM is different…and complementary!**
  - **Incorporates information flow & process control**
    - **Lean Operations focus on "the process," but not the employees or organizational design supporting that process**
    - **Other transformation efforts focus primarily on moving assets through the repair process (i.e., Theory of Constraints)**
  - **COM focuses on the HV Repair Cell's organizational c ectively c**

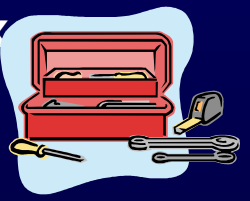


PREVIOUS WORK

- Organizational design & information-processing research
  - Galbraith (1973, 1974, & 1977)
- Validation of COM as a proven technique
  - Kuntz (1998); Nissen & Levitt (2002); Levitt & Kuntz (2002); Levitt (2004); and Kunz, Christiansen, Cohen, Jin, & Levitt (1998)
  - Computer tools to **understand relationship** between micro-theory, macro-theory, & organizational behavior
  - **Emulate real-world situations** within organizations
- Virtual Design Team (VDT)
  - Designed & tested by Dr. Levitt's research group at Stanford University (began late 1980's)
  - Commercialized in 1997 - SimVision™
  - **Developed educational use software (POWer 3.0a)**
  - Used by Shell Oil, AT&T, Dell, Dow, Applied Materials, Proctor & Gamble, Hewlett Packard, & American Airlines **as predictive tool**

PREVIOUS WORK (cont.)

- **Hagan & Slack (2006) – former NPS students**
  - **COM & simulation at Aircraft Intermediate Maintenance Division, NAS Lemoore, CA**
- **Dillard & Nissen (2007) – NPS faculty**
  - **Employ COM to assess behavior & project performance of different organizational designs in varying environments**
- **Ultimately COM:**
  - **Helps decision makers identify/examine potential impacts of organizational design changes before implementation**
  - **Provides decision makers quantitative evidence for enacting prospective design changes within organization**
  - **Is another tool for the decision-maker's toolbox**
  - **Improves visualization of the whole process**



METHODOLOGY

- **Understand how to use POWer 3.0a**
  - **Learn about model's characteristics & how to operate it**
  - **Identify data needed from HV Repair Cell (July 2007 site visit)**
- **Build baseline model *(from interviews & observations)***
  - **General properties**
    - ***Work day, work week, team experience, centralization, formalization, matrix strength, communication probability, noise probability, functional exception probability, & project exception probability***
  - **Major milestones**
  - **Tasks *(core & non-core HV Repair Cell tasks)***
  - **Positions**
  - **Meetings**
  - **Information transfer & decision-making policies/procedures**
  - **Rework links**
  - **Communication links**
  - **Knowledge links**
  - **Time lags to account for non-HV Repair Cell positions/tasks**

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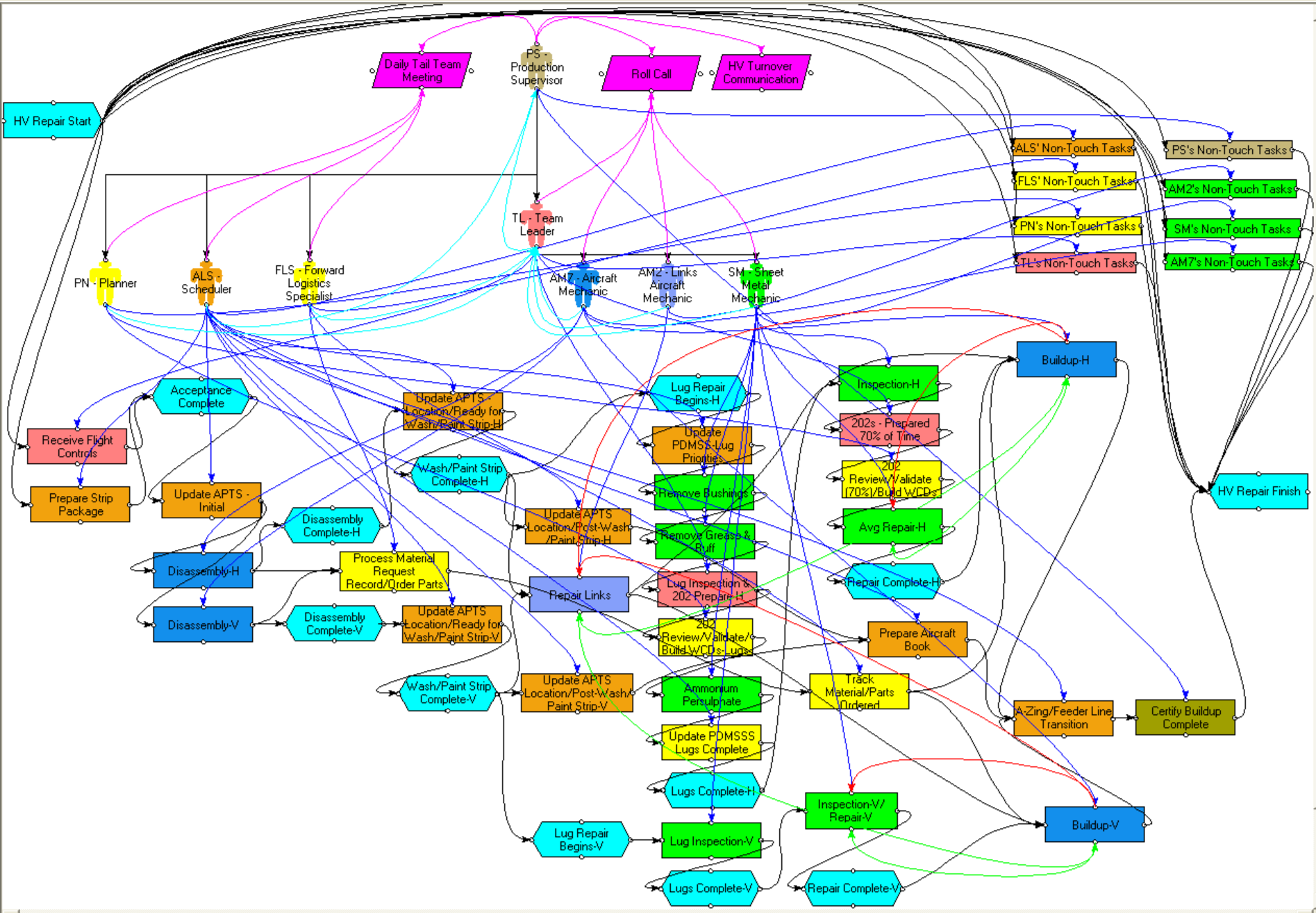


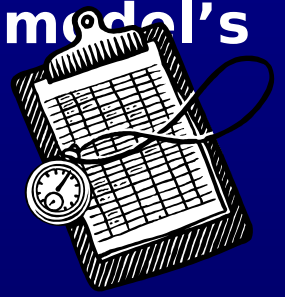
Full HV Repair | Practice Baseline | Baseline | Extra SM Mechanic | Create AM9 | Centralization, Med to Low | Functional Exception 10% | Crosstrain, 1 Mech Pool | Retirement | AM9 & Low Centralization | Creat AM9 w/Med Skills | Lower CommProb | Higher CommProb

METHODOLOGY (cont.)

- **Validate baseline model using Sensitivity Analysis**
  - **Change communication probability parameter**
    - **3 trials *(set to 10%, 20%, & 30% respectively)***
    - **"On any given day, there's a 10% (or 20/30%) chance an employee will need to communicate something about Work-in-Progress to another employee working an interdependent task"**
  - **Compare project duration output to historical repair time**
  - **Decision: model with 20% setting is most approximate**
    - **34.32 days within 1.9% of historical 35-day turnaround time**
- **Develop interventions *(alternative courses of action)***
  - **Feasible organizational design & work process modifications to improve time, cost, &/or repair risk**
  - **Simulate & analyze 7 interventions made to the baseline**
  - **Evaluate time, cost, & risk tradeoffs *(provided by each model's output)***

FINDINGS

- **Narrowed focus to 8 output values for each simulation**
- **Analyzed & compared each intervention model's results to the baseline model's results**



1) **Simulated project duration**
2) **Direct work time**
3) **Indirect work time**
   - **Rework, coordination, & exception-handling wait times**
4) **Total direct & indirect work time**
5) **Total project cost (*relative cost tied to the model's default costs*)**
6) **Total functional & project exception time**
   - **Functional exception work & project exception work times**
7) **Project risk *(risk that "finished" repair task was done incorrectly)***
8) **Position backlog**

FINDINGS (cont.)

Output for Baseline Model & Each Intervention

Numerical Output	Baseline Model Starting Point	Intervention 1 Add One SM Mechanic	Intervention 2a Create AM9 Aircraft Mech Position (Med Skills)	Intervention 2b Create AM9 Aircraft Mech Position (High Skills)	Intervention 3 Change Centralization from Med to Low	Intervention 4 Functional Exception from 5% to 10%	Intervention 5 Combination (AM 9 Position & Low Centralization)	Intervention 6 Crosstrain/ 1 Mechanic Resource Pool	Intervention 7 Retirement
Simulated Project Duration - (days)	34.32	33.90	34.21	33.46	34.15	34.98	33.51	29.42	35.03
Direct Work Time - (days)	130.52	130.52	127.90	127.90	130.52	130.52	127.90	125.27	130.52
Indirect (Hidden) Work Time (days):	30.85	31.43	33.24	31.22	29.83	43.36	30.03	26.74	47.29
Rework Time - (days)	*5.03*	*5.14*	*4.93*	*4.96*	*4.92*	*10.06*	*4.75*	*3.64*	*10.27*
Coordination Time - (days)	*18.31*	*18.72*	*18.82*	*18.65*	*18.15*	*19.41*	*18.70*	*17.42*	*22.06*
Exception-Handling Wait Time - (days)	*7.51*	*7.57*	*9.50*	*7.61*	*6.76*	*13.89*	*6.58*	*5.68*	*14.95*
Total Direct & Indirect (Hidden) Time - (days)	161.38	161.95	161.14	159.12	160.35	173.88	157.93	152.01	177.81
Total Project Cost - ($)	$60,627.98	$60,841.87	$64,767.71	$56,739.93	$60,224.56	$65,543.84	$56,280.97	$60,453.35	$67,813.97
Total Functional & Project Exception Time - (days)	8.74	8.71	9.27	8.86	8.64	16.61	8.43	9.31	17.51
Functional Exception Work - (days)	*7.95*	*7.82*	*8.34*	*7.81*	*7.82*	*15.71*	*7.47*	*8.19*	*15.99*
Project Exception Work - (days	*0.77*	*0.88*	*0.92*	*1.04*	*0.81*	*0.89*	*0.95*	*1.11*	*1.51*
Project Risk	0.07	0.08	0.09	0.10	0.08	0.08	0.09	0.06	0.12
Position Backlog - (days)	2.87	2.85	1.69	1.55	2.87	2.98	1.51	1.43	2.97
Position With Highest Backlog	AM2 - Links Aircraft Mechanic	AM2 - Links Aircraft Mechanic	TL - Team Leader	TL - Team Leader	AM2 - Links Aircraft Mechanic	AM2 - Links Aircraft Mechanic	TL - Team Leader	TL - Team Leader	AM2 - Links Aircraft Mechanic

FINDINGS (cont.)

Output Parameter Rankings

Output Parameter	Baseline Model Output	Best Model and Output	2nd Best Model and Output	3rd Best Model and Output
Simulated Project Duration - (days)	34.32	Intervention 6 29.42	Intervention 2b 33.46	Intervention 5 33.51
Direct Work Time - (days)	130.52	Intervention 6 125.27	Interventions 2a, 2b, 5 127.90	Baseline, Interventions 1, 3, 4, 7 130.52
Indirect (Hidden) Work Time - (days):	30.85	Intervention 6 26.74	Intervention 3 29.83	Intervention 5 30.03
Rework Time - (days)	*5.03*	Intervention 6 3.64	Intervention 5 4.75	Intervention 3 4.92
Coordination Time - (days)	*18.31*	Intervention 6 17.42	Intervention 3 18.15	Baseline 18.31
Exception-Handling Wait Time - (days)	*7.51*	Intervention 6 5.68	Intervention 5 6.58	Intervention 3 6.76
Total Direct & Indirect (Hidden) Time - (days)	161.38	Intervention 6 152.01	Intervention 5 157.93	Intervention 2b 159.12
Total Project Cost - ($)	$60,627.98	Intervention 5 $56,280.97	Intervention 2b $56,739.93	Intervention 3 $60,224.56
Total Functional & Project Exception Time - (days):	8.74	Intervention 5 8.43	Intervention 3 8.64	Intervention 1 8.71
Functional Exception Work - (days)	*7.95*	Intervention 5 7.47	Intervention 2b 7.81	Interventions 1, 3 7.82
Project Exception Work - (days)	*0.77*	Baseline 0.77	Intervention 3 0.81	Intervention 1 0.88
Project Risk	0.07	Intervention 6 0.06	Baseline 0.07	Interventions 1, 3, 4 0.08
Position Backlog - (days)	2.87	Intervention 6 1.43	Intervention 5 1.51	Intervention 2b 1.55
Position With Highest Backlog	AM2 - Links Aircraft Mechanic	TL - Team Leader	TL - Team Leader	TL - Team Leader

RECOMMENDATIONS

- **Address current hiring & operating regulations that prevent formal cross-training of mechanics within the HV Repair Cell (e.g., Collective Bargaining Agreement)**
- **Continue with informal cross-training of aircraft & sheet metal mechanics**
  - **Expand number of cross-training tasks as time/effort permit**
- **Train & fully qualify all 9 aircraft mechanics in disassembly, repair linkages, & buildup tasks to create 1 aircraft mechanic position (aim for high-level skills)**
- **Develop a "HV Repair Cell Transition Plan" to prepare organization for employees becoming retirement-eligible**
  - **Managers provide feedback, share plan for back-fills (if any), & clearly explain expectations to remaining employees**

CONCLUSION

- Greater appreciation of risk provides **objective awareness**
- Simulating alternative organizational designs to identify consequences prior to executing is valuable
- Unit's communication & information-transfer abilities directly impact repair cycle-time, cost, & quality
- Applying COM to other maintenance organizations would further support DoD transformation efforts/initiatives
- **BOTTOM LINE:** Increasing visualization & transparency of process before implementing planned organizational design changes **improves decision-making!!**